PCB DRILLING USING ARDUINO

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ABSTRACT

PCB drilling machine is used to drill holes on the PCB in order to provide component mounting and to make electrical interconnection between the bottom and top of the PCB. PCB drilling machine can be divided into two types. One is Manual Controlled Machines and the other is Computer Numerically Controlled Machine. This project is focusing on the designs and fabricates a prototype of low cost 3 axes PCB drilling machine. Arduino Uno is used as the main controller of the PCB drilling machine to control the motors and other electrical components. The PCB drilling machine is specific designed for single sided PCB only.

ABSTRAK

Mesin gerudi PCB digunakan untuk menyediakan komponen pemasangan dan membuat sambungan elektrik antara bahagian bawah dan atas PCB. Mesin gerudi PCB boleh dibahagikan kepada dua jenis. Mesin Pertama ialah mesin Kawalan manual dan satu lagi ialah mesin kawalan komputer berangka. Projek ini menekan kepada rekabentuk dan memalsukan prototaip mesin PCB yang kos rendah. Arduino Uno digunakan sebagai pengawal utama mesin gerudi untuk mengawal motor dan komponen elektrik yang lain. Mesin penggerudian direka untuk “single sided PCB”sahaja.

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LIST OF SYMBOLS

t_{ij}	Travelling time for the drill bit
V_X	Linear velocities in the x directions
V_Y	Linear velocities in the y directions
F	Feed rate
D	Diameter of the drill bit
N	Rotational speed of drilling bit
ω	Angular speed of the spindle

LIST OF ABBREVIATIONS

PCB	Printed Circuit Board
MRR	Material removal rate

CHAPTER 1

INTRODUCTION

1.0 Introduction

Chapter I is the Introduction of the overall project which included Project Background Problem Statement, Objective of project as well as Scope of Project are highlighted in this chapter.

1.1 Background of Study

Printed Circuit Board, PCB is invented by an Austrian inventor born in Vienna called Paul Eisler in 1936. [1] It is a board made of glass reinforced plastic with conductive line printed onto board. [2] Electrical and electronic components such as resistor, inductor, capacitor, and many more are mounted on the board and connected by conductive line printed onto board instead of wire in order to form a complete circuit. Holes are necessary to be drilled on the PCB in order to mount electronic components on the PCB. A normal drilling machine does not suitable to drill holes on a PCB.

In order to overcome this issue, it is essential to develop a machine called PCB drilling machine. In the Printed Circuit Board manufacturing, PCB drilling process is very important. There are two purpose of drilling operation. First is to provide component lead mounting and with structural integrity and another one is to make an electrical interconnection between top and bottom of the board. [3]

PCB drilling machine can be divided into two types. One is Manual Controlled Machines and the other is Computer Numerically Controlled Machine. A manual controlled PCB machine requires an operation in order to position the work piece and initiate the drilling cycle. Computer Numerical controlled (CNC) machine requires inputs from the computer to positioning and initiate the drilling cycles. The quality of a drilled hole is depends on various factors such as drilling techniques, quality of the drilling tool, and operator skill in control. Therefore, it is important to give a great attention on drilling operation.

The PCB drilling machine must be able to work in precise and accurate. PCB drilling machine can moves in 3 axes (X, Y, Z) in order to drill holes on PCB depends on the coordinate projected manually or automatically. In the industry, complex and expensive PCB drilling machine is designed and used to do the drilling process but a simple and cheat PCB drilling machine can be made by using various microcontrollers as well. Among these microcontroller that available for develop a PCB drilling machine, Arduino is the one that was studied in this research study. Arduino is a very small computer used to read variety of sensors or switches. Besides that, Arduino can be used to control variety of motor such DC motor and stepper motor and light emitting diode. Furthermore, it can be used to communicate with software running on a computer in a project.

1.2 Problem Statement

Drilling process is a very important stage in the PCB manufacturing. The PCB drilling machine is developed as the substitution of the manual drilling but the price of a PCB drilling machine is expensive nowadays. Besides that, the holes drilled by manual are not accurate and consistent compared to machine.

1.3 Objective of Project

I To design a PCB drilling machine with high accuracy to locate the holes to be drilled

II To fabricate a 3 axes low cost PCB drilling machine

1.4 Scope of Project

I Designing a PCB drilling machine by using Catias

II Fabricating a PCB drilling machine using CNC and milling machine

III Controlling stepper motors by using Arduino board and CNC shield

1.5 Thesis Outlines

This thesis comprised of five chapters which are as follows; Introduction, Literature Review, Methodology, Result analysis and Discussion and Conclusion respectively.

- Chapter I is the Introduction of the overall PCB drilling machine project which included Project Background Problem Statement, Objective of project as well as Scope of Project are highlighted in this chapter.

- Chapter II is to provide some information about the theory related to the thesis subject.

- Chapter III is covers with methodology of the project. The process and methods that were employed to complete the project are discussed in this chapter. As the project includes both hardware and software developments, therefore components and implementations used are discussed in detail in this section.

- Chapter IV is covers with the result and discussion of the project. The picture of the project is shown in this chapter. The problems in making the PCB drilling machine are discussed in this chapter too.

- Chapter V is the conclusion and recommendation of the overall project.

CHAPTER 2

LITERATURE REVIEW

2.1 **Stepper Motor**

A stepper motor is a dc motor which convert electrical pulse into discrete mechanical movement [4]. A stepper motor rotates in discrete steps and each step is the same size when there are electrical pulses applied to it. The size of step is measured in degree. Typical size of a step is 0.9 or 1.8 degrees and a stepper motor rotates a full rotation with 200 steps or 400 steps. It can be rotated in both directions, clockwise and anticlockwise. Stepper motor rotates with precision angle in each step. [5] The holding torque of stepper motor is strongest at zero speed whereas low or even no holding torque at high speed. The speed of the stepper motor is depending on the frequency of electrical pulses and the number of rotation is depending on the number of electrical pulses [6]. One of the disadvantages of the stepper motor is more vibration than other motor.

Figure 2.1 stepper motor

There are three basic types of stepper motor:

1. Variable reluctance stepper
2. Permanent magnet stepper
3. Hybrid stepper

2.1.1 Variable reluctance stepper

Variable reluctance stepper motor consists of an irregularly shaped soft iron magnetic rotor. [7] The field strength is adjustable since it does not using permanent magnet. The rotor of variable reluctance stepper motor will move to complete a magnetic circuit in order to minimize the length of any high reluctance air gap [2]. The resolution can be increased as more teeth are added.

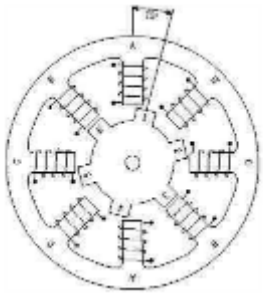

Figure 2.2 Horizontal cross section of variable reluctance stepper motor

2.1.2 Permanent magnet stepper motor

A permanent magnet stepper motor consists of a cylindrical magnetic rotor and it is called Canstack Rotor. [7] It is a type of low resolution stepper motor and it has a large stepping angle of 7.5° to 18°. The operation of a permanent magnet stepper motor is based on the repulsion or attraction between the rotor and the stator.

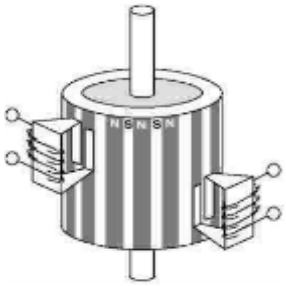

Figure 2.3 Illustration of permanent magnet stepper motor

2.1.3 Hybrid stepper motor

The hybrid stepper motor combined the feature of variable reluctance and permanent magnet stepper motor in order to rotate in smaller steps. [7] A standard hybrid stepper motor rotates 1.8 degree in each step and its rotor has 200 teeth. Normally, it is used in the application such as printer, CD player and many more.

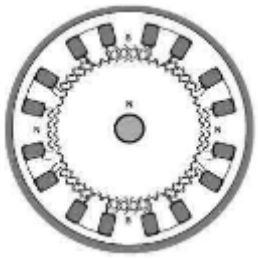

Figure 2.4 Horizontal cross section of hybrid stepper motor

Stepper motor can be divided into two types regarding the method of motor winding design. One is bipolar stepper motor and another one is unipolar stepper motor:

2.1.4 Bipolar stepper motor

Bipolar stepper motors have a single winding per phase. The magnetic pole can be reversed if the current in a winding is reversed. Normally, there are four wires and no com in a bipolar stepper motor. [8]

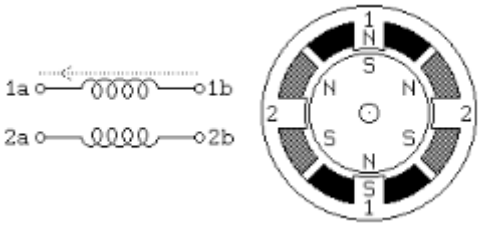

Figure 2.5 Bipolar Stepper motor

2.1.5 Unipolar stepper motor

Bipolar stepper motors have two winding per phase. The magnetic pole can be reversed without changing the direction of current. Normally, there are five wires and a com in a unipolar stepper motor. [8]

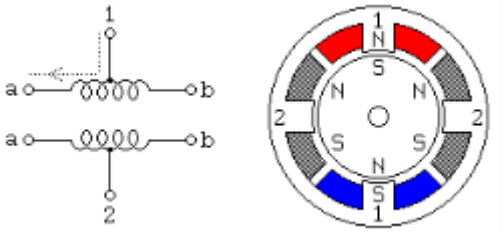

Figure 2.6 Unipolar Stepper motor

2.2 Limit switch

Limit switch is an electrical mechanical device which used as sensor to determine location of an object. It consist an actuator mechanically linked to a set of contacts. Limit switch contact or break an electrical connection if there is any object come in contact with the actuator. There are several types of limit switches and there are classified based on their application. Limit switch can be divided into two types regarding on the limit switch contact. One is normally open (NO) and another one is normally closed (NC). The pin in between the pin of normally closed and open is the com. [9]

Figure 2.7Limit Switch

2.3 **Microcontroller**

Arduino is a small computer on a single integrated circuit containing processor core, memory, and programmable input and output peripheral. Normally we called it as microcontroller. Arduino used to read variety of sensors or switches. Besides that, Arduino can be used to control variety of motor and light emitting diode. Arduino can be used to communicate with software running on a computer in a project. IDE is a compiler that runs on computer which is used to read and upload sketches into Arduino. Arduino called programming code as sketch. Code can be transferred by connecting Arduino to computer using USB cable. In this thesis project, Atmel ATmega2560 microcontroller is focus to be the controller. [10] The picture of Arduino Mega microcontroller board is shown in figure below:

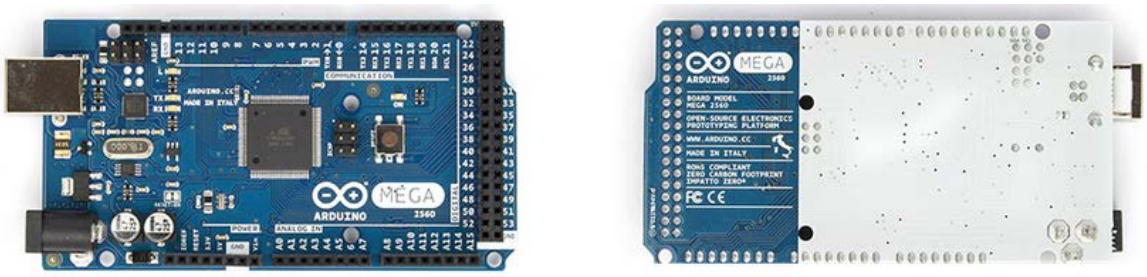

Figure 2.8 Arduino Mega Board Front and Back

Microcontroller Chip	ATmega2560
Operation Voltage	5 V
Input Voltage	6 V – 20V
Digital Input Output Pins	54
PWM Pins	15
Analog Output Pins	16
Dc Current Per Input Output Pins	40 mA
Flash Memory	256 kB
SRAM	8 kB
EEPROM	4 kB
Clock Speed	16 MHz

Specification of Arduino Mega board

Pin Configuration of Atmel ATmega2560

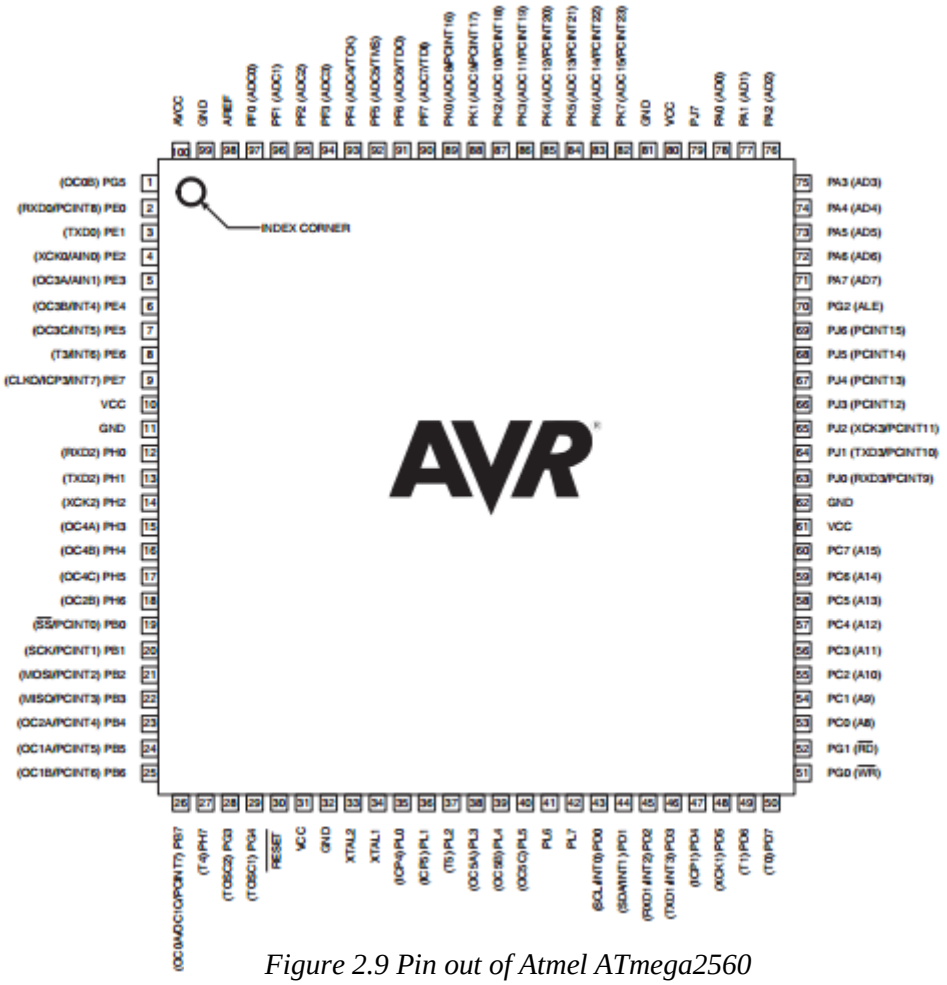

Figure 2.9 Pin out of Atmel ATmega2560

Pin Descriptions of Atmel Atmega2560

VCC Digital supply voltage

GND Ground

Port A - L Port A-L is an 8-bit bi-directional I/O port with internal pull-up resistors. The Port A-L output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port A-L pins that are externally pulled low will source current if the pull-up resistors are activated. The Port A-L pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Reset Reset input. This pin will generate a reset if there is a low level on this pin for longer than the minimum pulse length, even if the clock is not running.

XTAL1 Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2 Output from the inverting Oscillator amplifier.

AVCC AVCC is the supply voltage pin for Port F and the A/D Converter. It is externally connected to VCC.

AREF This is the analog reference pin for the A/D Converter.

2.4 **Stepper motor driver**

Motor drivers are designed to drive an electromagnetic load. It can be stepper motor, Dc motor, Dc gear motor, relay, solenoid, etc. The voltage produce from output pin of microcontroller is not high enough to operate a stepper motor. Normally, a stepper motor is needed 12 to 24 voltages to drive it. So a motor driver is needed to amplifier the voltage from 5 volt to 12 – 24 volt in order to make a stepper motor run. In this thesis project, L293D is focus to be the motor driver. [11] The pin diagram of L293D is shown in figure below:

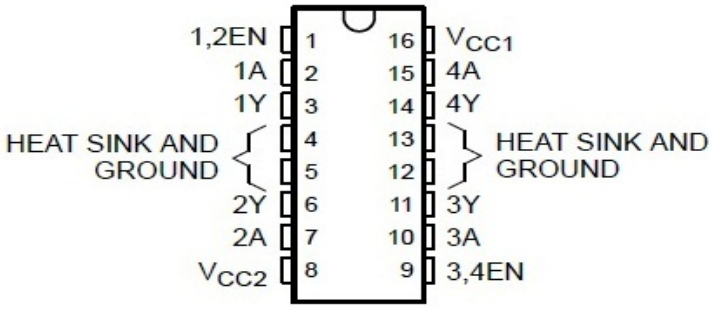

Figure 2.10 Pin diagram of L293D

2.5 **Power supply**

Power supply is an electronic device which is used to supply voltage to some electrical device. Some of the power supply may have the feature to convert the magnitude of power supply. In this thesis project, NES-25 is focus to be the power supply. The picture of NES-25 is shown in figure below:

Figure 2.11 NES -25

2.6 **PCB (Printed Circuit Board)**

Printed Circuit Board, PCB is invented by an Austrian inventor born in Vienna called Paul Eisler in 1936. It is a board made of glass reinforced plastic with conductive line printed onto board. Holes are necessary to be drilled on the PCB in order to mount electrical and electronic components such as resistor, inductor, capacitor, and many more are mounted on the board and connected by conductive line printed onto board instead of wire in order to form a complete circuit.

2.7 **X – Y drive system concept**

Moving of drill bit of a machine is an important consideration in early stage of mechanical part designed of machine. [12] Load should be kept to a minimum in order to keep the motor size down. One of the solutions is to keep the drill bit stationary and using a flexible drive shaft. Coordinate system used in a machine also affects the accuracy of positioning the holes location. For example, Cartesian coordinate system works more accuracy than polar coordinate and cylindrical coordinate system. The reason is polar coordinate and cylindrical coordinate system has greater positioning error with the respect of fulcrum.

There are three possibility of X - Y drive system in the Cartesian coordinate system:

1. The drill bit will move in X and Y axis but the PCB is stationary. This option gives the minimum area required but it is a maximum load option.

Figure 2.12 Twin axis arrangements

2. Both the drill bit and PCB are moving. Drill bit move in X – axis and PCB move in Y – axis or PCB move in X – axis and Drill bit move in Y – axis.

Figure 2.13 Separate split axis arrangement